



June 17, 2013

Via email: docket@energy.ca.gov

California Energy Commission
Dockets Office, MS-4
1516 Ninth Street
Sacramento, CA 95814-5512

California Energy Commission

DOCKETED
13-IEP-1M

TN 71310

JUN 17 2013

**Re: Status of Bioenergy Development in California
(Docket No. 13-IEP-1M)**

Dear Commissioners and Staff:

Thank you for inviting the Center for Biological Diversity (“Center”) to participate in the Commission’s June 3, 2013 Staff Workshop on the Status of Bioenergy Development in California. The Center is a non-profit environmental organization dedicated to the protection of imperiled species, their habitats, and the environment through science, policy, and environmental law. The Center has more than 500,000 members and online activists throughout the United States, including many in California. The goal of the Center’s Climate Law Institute is to reduce U.S. greenhouse gas emissions and other air pollution to protect biological diversity, the environment, and public health. Specific objectives include securing protections for species threatened by the impacts of global warming, ensuring compliance with applicable law in order to reduce greenhouse gas emissions and other air pollution, and educating and mobilizing the public on global warming and air quality issues.

These comments elaborate on and provide additional support for the Center’s presentation at the June 3 workshop. Many presentations at the workshop referenced the purported environmental benefits of energy generation from forest-sourced biomass. As the Center’s presentation demonstrated, however, forest bioenergy also entails potentially significant adverse environmental impacts and costs, particularly with respect to air pollution, greenhouse gas emissions, water supply and quality issues, and effects on forest habitat associated with the harvest and combustion of woody biomass. Implementation of sound bioenergy policy in California requires proper consideration of the social and environmental costs of expanding forest biomass utilization.

I. Electricity Generation from Forest Biomass Can Increase Net Greenhouse Gas Emissions Over Significant Time Periods

Policy-makers have often assumed that replacing fossil-fueled electricity generation with bioenergy reduces greenhouse gas emissions. However, burning wood for electricity releases more carbon dioxide (CO₂) per megawatt of energy produced than

burning coal, and far more CO₂ than burning natural gas. This is because wood is less energy-dense, and contains more moisture, than fossil fuels. Measured at the smokestack, therefore, replacing fossil fuels with biomass actually *increases* CO₂ emissions.¹

All molecules of CO₂, whether from “biogenic” or fossil sources, exert the same warming influence on the climate.² Moreover, CO₂ from combustion of trees remains in the atmosphere for centuries, even if the trees eventually grow back. Multiple studies have shown that it can take a very long time—on the order of decades or centuries—for new biomass growth to recapture the carbon emitted by bioenergy production, even where fossil fuel displacement is assumed, and even where “waste” materials like timber harvest residuals are used for fuel.³ This increase in net greenhouse gas emissions over time is known as the “carbon debt” of bioenergy.

The timing of greenhouse gas emissions is critical to climate mitigation efforts.⁴ Climate scientists agree we need to reduce emissions dramatically in the short term and keep them down. Global greenhouse gas emissions must peak within the next few years and drop sharply thereafter in order to preserve a likely chance of keeping aggregate

¹ A recent application for an air permit to convert a 150 MW coal-fired facility in Florida to a 70-80 MW biomass facility illustrates the point. The coal plant produced about 750,000 metric tonnes of CO₂-equivalent greenhouse gases (MTCO₂e) per year. The smaller biomass plant, however, will produce more than 1 million tons of CO₂ alone—an increase in emissions of more than 25% in order to produce about 50% *less* energy. The air permit application and supporting documents are available at http://www.dep.state.fl.us/air/emission/bioenergy/central_power.htm (last visited June 16, 2013).

² Science Advisory Board Review of EPA’s Accounting Framework for Biogenic CO₂ Emissions from Stationary Sources 7 (Sept. 28, 2012) (hereafter “SAB Panel Report”).

³ See, e.g., Stephen R. Mitchell, et al., *Carbon Debt and Carbon Sequestration Parity in Forest Bioenergy Production*, Global Change Biology Bioenergy (2012), doi: 10.1111/j.1757-1707.2012.01173.x; Ernst-Detlef Schulze, et al., *Large-Scale Bioenergy from Additional Harvest of Forest Biomass Is Neither Sustainable Nor Greenhouse Gas Neutral*, Global Change Biology Bioenergy (2012), doi: 10.1111/j.1757-1707.2012.01169.x at 1-2; Jon McKechnie, et al., *Forest Bioenergy or Forest Carbon? Assessing Trade-Offs in Greenhouse Gas Mitigation with Wood-Based Fuels*, 45 Environ. Sci. Technol. 789 (2011); Anna Repo, et al., *Indirect Carbon Dioxide Emissions from Producing Bioenergy from Forest Harvest Residues*, Global Change Biology Bioenergy (2010), doi: 10.1111/j.1757-1707.2010.01065.x; Manomet Center for Conservation Sciences, *Massachusetts Biomass Sustainability and Carbon Policy Study: Report to the Commonwealth of Massachusetts Department of Energy Resources* (2010); Giuliana Zanchi et al., *The Upfront Carbon Debt of Bioenergy* (Joanneum Research May 2010); M. O’Hare et al., *Proper Accounting for Time Increases Crop-Based Biofuels’ Greenhouse Gas Deficit Versus Petroleum*, *Envtl. Res. Lett.* (2009), doi:10.1088/1748-9326/4/2/024001.

⁴ See O’Hare 2009, *supra* note 3.

global warming below 2°C—a level at which serious impacts will still occur.⁵ Yet the science shows this is precisely the time period during which bioenergy emissions released today will increase atmospheric CO₂ levels.

Many bioenergy proponents assume this effect can be avoided if forest “waste” and “residues” are used for bioenergy. This assumption, however, is incorrect. As a threshold matter, these terms have no stable definition, and in practice are used to mean anything from slash left over from logging operations, to wood from urban demolition projects, to live, growing trees thinned for wildfire prevention or other reasons. Moreover, treating all “waste” materials as if they are automatically carbon neutral creates a perverse incentive to categorize additional kinds of materials as “waste,” and to use more of the “waste” already out there. This can also affect the carbon balance of bioenergy. Studies have shown that changes in forest management practices, including the increased use of harvest residues for bioenergy, can reduce overall terrestrial carbon storage.⁶ Research also shows intensive forestry operations may release significant amounts of carbon stored in forest soils.⁷

Determining the atmospheric effect of burning any woody material—including “waste” and “residues”—requires analysis of what would have happened to the material if it were not used as fuel. For example, slash and residual wood left over from a logging operation will eventually decompose, releasing at least some of the stored carbon to the atmosphere (though some fraction of the carbon may remain stored for a longer period in the forest soil). Different sizes and kinds of wood decompose at different rates; while smaller branches and stems may decompose in a few years, stumps and other large pieces of wood can take decades to break down.⁸ Bioenergy production, in contrast, results in an immediate emission of CO₂ to the atmosphere. Accordingly, even burning “waste” material incurs a carbon debt for at least the period of time that would have been required for the material to decompose naturally.⁹

⁵ Joeri Rogelj, et al., *Emission Pathways Consistent with a 2° Global Temperature Limit*, 1 Nature Climate Change 413 (2011).

⁶ See Kim Pingoud, et al., *Global warming potential factors and warming payback time as climate indicators of forest biomass use*, Mitig. Adapt. Strateg. Glob. Change (2011), doi:0.1007/s11027-011-9331-9.

⁷ See, e.g., Thomas Buchholz, et al., *Mineral Soil Carbon Fluxes in Forests and Implications for Carbon Balance Assessments*, Global Change Biology Bioenergy (2013), doi: 10.1111/gcbb.12044; Robert Jandl, et al., *How Strongly Can Forest Management Influence Soil Carbon Sequestration?* 137 Geoderma 253 (2007), doi:10.1016/j.geoderma.2006.09.003.

⁸ Repo 2010, *supra* note 3.

⁹ The SAB Panel Report highlighted the need for consideration of this delay in natural decomposition when accounting for emissions from burning forest-derived “waste” materials. SAB Panel Report, *supra* note 2 at 5.

Natural decomposition is important not only in terms of time scale, but also in terms of the resulting emissions. Discussions of the purported greenhouse gas benefits of forest bioenergy often erroneously assume that decomposition of “waste” forest materials results in significant emissions of methane, a powerful greenhouse gas; by burning “waste” for energy, the argument goes, methane emissions are avoided. Methane, however, is produced only under anaerobic conditions—such as in wetlands—that are very unlikely to occur in typical California forests. Anaerobic decomposition also occurs in landfills.¹⁰ However, slash, thinnings, and other forest “waste” materials are almost never disposed in landfills, but rather are typically left in the forest or burned on site. Methane simply is not a significant factor in decomposition of forest materials. As a result, significant methane emissions are not “avoided” by using forest materials for bioenergy, and cannot offset the greenhouse gas emissions caused by fuel combustion.¹¹

Trees thinned as part of wildfire prevention (“fuels reduction”) projects are often described as “residues.” From an atmospheric perspective, however, use of these materials for bioenergy incurs a carbon debt consistent with what these materials generally are: live, growing trees that are currently sequestering carbon and would continue to do so if not removed from the forest.

Indeed, two recently published studies of forests in the western United States suggest that using forest thinnings for bioenergy may increase net greenhouse gas emissions for significant periods of time, even when potentially avoided emissions from high-intensity wildfires are taken into account. The first study, led by John L. Campbell of Oregon State University, found “little credible evidence” that fuel reduction projects increased forest carbon stock.¹² Campbell identified several reasons for this. For example, the amount of carbon lost through fuels reduction projects tends to exceed the amount of carbon those fuel removal projects prevent from being emitted during a fire. This is partly because most fire-related emissions are associated with combustion of fine materials like branches and needles; because these materials tend to burn no matter how hot the fire, the difference in emissions between a high-intensity fire in an untreated stand and a low-intensity fire in a treated stand is not that great. It is not practical to “thin” branches and needles without also removing the trees to which they are attached.

¹⁰ Even under anaerobic conditions in landfills, wood tends not to decompose at all, and accordingly does not produce significant quantities of methane. See J.A. Micales & K.E. Skog, *The Decomposition of Forest Products in Landfills*, 39 Int’l Biodeterioration & Biodegradation 145 (1997).

¹¹ Bioenergy facilities themselves, however, may be sources of methane and nitrous oxide emitted from long-term storage of wood chips in fuel stockpiles. See Biomass Tech. Group BV, *Methane and Nitrous Oxide Emissions from Biomass Waste Stockpiles* (2002), available at http://wbcarbonfinance.org/docs/CH4_emissions_from_woodwaste_stockpiles.pdf (last visited June 16, 2013).

¹² John L. Campbell, et al., *Can fuel-reduction treatments really increase forest carbon storage in the western US by reducing future fire emissions?* Front. Ecol. Env’t (2011), doi:10.1890/110057.

Campbell thus concluded that even in a fire-suppressed ponderosa pine forest, protecting one unit of carbon from combustion in a fire required removing three units of carbon in fuels. Moreover, because the probability of a fire on any given acre of forest is relatively low, forest managers must treat many more acres than will actually burn in order to get much of a benefit—again resulting in an increase in carbon removed relative to avoided combustion. Campbell also found that over a succession of disturbance cycles, models predicting forest growth, mortality, decomposition and combustion showed more carbon storage in a low-frequency, high-intensity fire regime than in a high-frequency, low-intensity fire regime. Only where disturbances caused a permanent change in forest productivity did Campbell find fuel treatments to have a profound influence on carbon storage.

Another Oregon State University researcher, Tara Hudiburg, led an investigation of forest carbon responses to three different levels of fuel reduction treatments in 19 West Coast ecoregions containing 80 different forest types and different fire regimes.¹³ Hudiburg found that in nearly all forest types, intensive harvest for bioenergy production resulted in net carbon emissions to the atmosphere, at least over the 20-year time frame of the study. Only in forest ecoregions currently functioning as net carbon sources did bioenergy production result in decreased emissions. The positive carbon emissions of bioenergy persisted even in a lighter-touch fire prevention scenario in most ecoregions. The study acknowledged that if forests currently serving as carbon sinks were to become sources in the future, the effect of bioenergy production might be different—but at present, across a wide range of ecosystems, forest bioenergy increases carbon dioxide concentrations, at least in the short term.

Both papers recognize that forest managers may have non-climate-related reasons for undertaking certain thinning projects. Both papers also make clear, however, that these projects have climatic consequences that must be considered when evaluating the overall costs and benefits of forest bioenergy production.

II. Increased Thinning for Wildfire Prevention Overlooks the Natural Occurrence and Ecological Importance of High-Severity Fire

Many of the major benefits often ascribed to forest bioenergy production are derived from the assumption that the construction of biomass power plants will create a market for chips from small-diameter trees, and thus will help facilitate additional forest thinning projects that reduce the risk of “catastrophic” (high-intensity, high-severity) wildfire. The perceived value of this benefit, however, depends on the further assumption that high-severity fire is both “unnatural” and always environmentally destructive. This latter assumption is not borne out by the available empirical evidence,

¹³ Tara Hudiburg, et al., *Regional carbon dioxide implications of forest bioenergy production*, Nature Climate Change (2011), doi: 10.1038/NCLIMATE1264.

as demonstrated in the attached summary of current fire science literature compiled by the Center and the John Muir Project of Earth Island Institute.¹⁴

Of course, forest treatments immediately adjacent to communities and infrastructure can help protect against damage and loss from wildfire. That said, the science does not indicate that a wide-scale effort to essentially eliminate high-severity fire from California's forests is either necessary or ecologically beneficial.

III. Site-Specific Review of Bioenergy Projects Is Essential to Understanding Environmental Consequences

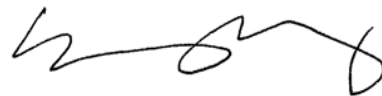
Policy-level discussions tend to assume that forest bioenergy facilities produce similar benefits. However, the environmental impacts of any particular facility will vary depending on the local setting, feedstock sourcing, and other site-specific conditions. Site-specific analysis of each facility's environmental impact is therefore critical.

For example, although producing bioenergy from slash that otherwise would have been burned in the open can reduce certain air pollutant emissions on a mass basis, the bioenergy facility will tend to concentrate what otherwise would be temporary and geographically dispersed emissions in a single location over a far longer period of time. Different bioenergy facilities also use and discharge different amounts of water and wastewater. These site-specific conditions must be considered in evaluating relative costs and benefits.

In addition, both site-specific and cumulative analysis is critical to understanding the effect of placing multiple energy facilities—such as those resulting from implementation of SB 1122—on the forested landscape. If sited without a comprehensive understanding of cumulative effects, these facilities could compete for feedstocks in a manner that may cause overharvesting and environmental damage.

Again, thank you for inviting the Center to participate in the June 3 workshop, and for your consideration of these additional comments. We stand ready to work with Commissioners and staff to address these and other important policy issues presented by the use of forest biomass for energy production in California.

Sincerely,



Kevin P. Bundy
Senior Attorney

Cc: Garry (O'Neill) Mariscal (via email)

¹⁴ Chad Hanson, Ph.D., and Justin Augustine, Relevant Scientific Literature Reference List (May 15, 2013) (attached as Ex. A).



Relevant Scientific Literature Reference List:

- 1) **Mixed-severity fire is not limited to true fir and lodgepole pine; mixed-severity fire, including a significant proportion of high-severity fire and occasional large high-severity fire patches hundreds or thousands of acres in size, is also a natural condition in ponderosa-pine/Jeffrey-pine and mixed-conifer forest, and generally dominated pre-fire suppression fire regimes in these forest types.**

Baker, W.L. 2006. Fire history in ponderosa pine landscapes of Grand Canyon National Park: is it reliable enough for management and restoration? *International Journal of Wildland Fire* 15: 433-437.

Baker, W.L. 2012. Implications of spatially extensive historical data from surveys for restoring dry forests of Oregon's eastern Cascades. *Ecosphere* 3(3): article 23. *(In dry mixed-conifer forests of the eastside of the southern Cascades, historic fire was 24% low-severity, 50% mixed-severity, and 26% high-severity [Table 5].)*

Baker, W.L., T.T. Veblen, and Sherriff, R.L. 2007. Fire, fuels and restoration of ponderosa pine-Douglas-fir forests in the Rocky Mountains, USA. *Journal of Biogeography*, 34: 251-269.

Beaty, R.M., and A.H. Taylor. 2001. Spatial and temporal variation of fire regimes in a mixed conifer forest landscape, Southern Cascades, USA. *Journal of Biogeography* 28: 955-966. *(On the western slope of the southern Cascades in California, historic fire severity in mixed-conifer forests was predominantly moderate- and high-severity, except in mesic canyon bottoms, where moderate- and high-severity fire comprised 40.4% of fire effects [Table 7]. Contrary to the occasionally stated assumption that the forests studied in the southern Cascades of California allowed more high-severity fire than the western slope of the central and southern Sierra Nevada due to gentle and unbroken topography that allowed large "runs" of fire, and due to different conifer forest types and precipitation levels, the study area was mostly on moderate to steep slopes, with forest frequently broken by peaks, rock outcroppings, and water bodies [Fig. 1], the annual precipitation is similar to the southern/central Sierra Nevada's western slope (134 cm/yr, mostly as snow), and the composition of conifers in mixed-conifer forest is the same as in the southern/central Sierra Nevada, comprised of ponderosa and Jeffrey pine, white fir, incense-cedar, sugar pine, and Douglas-fir.)*

Bekker, M. F. and Taylor, A. H. 2001. Gradient analysis of fire regimes in montane forests of the southern Cascade Range, Thousand Lakes Wilderness, California, USA. *Plant Ecology* 155: 15-28. *(On the western slope of the southern Cascades in California, in mixed-conifer*

forests, fire severity was predominantly high-severity historically [Fig. 2F]. Contrary to the occasionally stated assumption that the forests studied in the southern Cascades of California allowed more high-severity fire than the western slope of the central and southern Sierra Nevada due to gentle and unbroken topography that allowed large “runs” of fire, and due to different conifer forest types and precipitation levels, the study area was mostly on moderate to steep slopes, with forest frequently broken by peaks, rock outcroppings, and water bodies [Fig. 1], the annual precipitation is similar to the southern/central Sierra Nevada’s western slope (105 cm/yr, mostly as snow), and the composition of conifers in mixed-conifer forest is the same as in the southern/central Sierra Nevada, comprised of ponderosa and Jeffrey pine, white fir, incense-cedar, and sugar pine [Table 1].)

- Bekker, M. F. and Taylor, A. H. 2010. Fire disturbance, forest structure, and stand dynamics in montane forest of the southern Cascades, Thousand Lakes Wilderness, California, USA. *Ecoscience* 17: 59-72. *(In mixed-conifer forests of the southern Cascades, reconstructed fire severity was dominated by high-severity fire effects, including high-severity fire patches over 2,000 acres in size [Tables I and II]. Contrary to the occasionally stated assumption that the forests studied in the southern Cascades of California allowed more high-severity fire than the western slope of the central and southern Sierra Nevada due to gentle and unbroken topography that allowed large “runs” of fire, and due to different conifer forest types and precipitation levels, the study area was mostly on moderate to steep slopes, with forest frequently broken by peaks, rock outcroppings, and water bodies [Fig. 1], the annual precipitation is similar to the southern/central Sierra Nevada’s western slope (105 cm/yr, mostly as snow), and the composition of conifers in mixed-conifer forest is the same as in the southern/central Sierra Nevada, comprised of ponderosa and Jeffrey pine, white fir, incense-cedar, and sugar pine [Fig. 2].)*
- Brown, P.M., M.R. Kaufmann, and W.D. Shepperd. 1999. Long-term, landscape patterns of past fire events in a montane ponderosa pine forest of central Colorado. *Landscape Ecology* 14: 513-532.
- Collins, B.M., and S.L. Stephens. 2010. Stand-replacing patches within a mixed severity fire regime: quantitative characterization using recent fires in a long-established natural fire area. *Landscape Ecology* 25: 927-939. *(In a modern “reference” forest condition within mixed-conifer/fir forests in Yosemite National Park, 15% of the area experienced high-severity fire over a 33-year period—a high-severity fire rotation interval of approximately 223 years.)*
- Colombaroli, D. and D. G. Gavin 2010. Highly episodic fire and erosion regime over the past 2,000 y in the Siskiyou Mountains, Oregon. *Proceedings of the National Academy of Sciences* 107: 18909-18915.
- Hessburg, P. F., R. B. Salter, and K. M. James. 2007. Re-examining fire severity relations in pre-management era mixed conifer forests: inferences from landscape patterns of forest structure. *Landscape Ecology* 22:5-24.

- Iniguez, J. M., T. W. Swetnam, and C. H. Baisan. 2009. Spatially and temporally variable fire regime on Rincon Mountain, Arizona, USA. *Fire Ecology* 5:3-21.
- Klenner, W., R. Walton, A. Arsenault, L. Kremsater. 2008. Dry forests in the Southern Interior of British Columbia: Historical disturbances and implications for restoration and management. *Forest Ecology and Management* 256: 1711-1722.
- Leiberg, J.B. 1897. General report on a botanical survey of the Coeur d'Alene Mountains in Idaho during the summer of 1895. United States Division of Botany, Contributions from the U.S. National Herbarium Volume V, No. 1, pp. 41–85. US Government Printing Office, Washington, DC.
- Leiberg, J.B. 1899a. Bitterroot Forest Reserve. USDI Geological Survey, Nineteenth Annual Report, Part V. Forest Reserves, pp. 253–282. US Government Printing Office, Washington, D.C.
- Leiberg, J.B. 1899b. Present condition of the forested areas in northern Idaho outside the limits of the Priest River Forest Reserve and north of the Clearwater River. USDI Geological Survey, Nineteenth Annual Report, Part V. Forest Reserves, pp. 373–386. US Government Printing Office, Washington, DC.
- Leiberg, J.B. 1899c. Priest River Forest Reserve. USDI Geological Survey, Nineteenth Annual Report, Part V. Forest Reserves, pp. 217–252. US Government Printing Office, Washington, DC.
- Leiberg, J.B. 1900a. Bitterroot Forest Reserve. USDI Geological Survey, Twentieth Annual Report to the Secretary of the Interior, 1898–99, Part V. Forest Reserves, pp. 317–410. US Government Printing Office, Washington, DC.
- Leiberg, J.B. 1900b. Sandpoint quadrangle, Idaho. USDI Geological Survey, Twenty-first Annual Report, Part V. Forest Reserves, pp. 583–595. US Government Printing Office, Washington, DC.
- Leiberg, J. B. 1900c. Cascade Range Forest Reserve, Oregon, from township 28 south to township 37 south, inclusive; together with the Ashland Forest Reserve and adjacent forest regions from township 28 south to township 41 south, inclusive, and from range 2 west to range 14 east, Willamette Meridian, inclusive. U.S. Geological Survey Annual Report 21(V):209-498.
- Leiberg, J. B. 1902. Forest conditions in the northern Sierra Nevada, California. USDI Geological Survey, Professional Paper No. 8. U.S. Government Printing Office, Washington, D.C. (*High-severity fire patches over 5,000 acres in size mapped in mixed-conifer forest that had not been logged previously during the 19th century, prior to fire suppression.*)
- Leiberg, J. B. 1903. Southern part of Cascade Range Forest Reserve. Pages 229–289 in H. D. Langille, F. G. Plummer, A. Dodwell, T. F. Rixon, and J. B. Leiberg, editors. Forest

conditions in the Cascade Range Forest Reserve, Oregon. Professional Paper No. 9. U.S. Geological Survey, U.S. Government Printing Office, Washington, D.C., USA.

Leiberg, J.B. 1904a. Forest conditions in the Absaroka division of the Yellowstone Forest Reserve, Montana. USDI Geological Survey Professional Paper No. 29, US Government Printing Office, Washington, DC.

Leiberg, J.B. 1904b. Forest conditions in the Little Belt Mountains Forest Reserve, Montana, and the Little Belt Mountains quadrangle. USDI Geological Survey Professional Paper No. 30, US Government Printing Office, Washington, DC.

Minnich, R.A., M.G. Barbour, J.H. Burk and J. Sosa-Ramirez, 2000. Californian mixed-conifer forests under unmanaged fire regimes in the Sierra San Pedro Martir, Baja California, Mexico. *Journal of Biogeography* 27: 105-129.

Nagel, T.A. and Taylor, A.H. 2005. Fire and persistence of montane chaparral in mixed conifer forest landscapes in the northern Sierra Nevada, Lake Tahoe Basin, California, USA. *J. Torrey Bot. Soc.* 132: 442-457.

Russell, W. H., J. McBride, and R. Rowntree. Revegetation after four stand-replacing fires in the Tahoe Basin. *Madrono* 45: 40-46.

Sherriff, R. L., and T. T. Veblen. 2007. A spatially explicit reconstruction of historical fire occurrence in the Ponderosa pine zone of the Colorado Front Range. *Ecosystems* 9:1342-1347.

Shinneman D.J. and W.L. Baker, 1997. Nonequilibrium dynamics between catastrophic disturbances and old-growth forests in ponderosa pine landscapes of the Black Hills. *Conservation Biology* 11: 1276-1288.

Show, S.B. and Kotok, E.I. 1924. The role of fire in California pine forests. United States Department of Agriculture Bulletin 1294, Washington, D.C. (*Historically, within ponderosa pine and mixed-conifer/pine forests of the Sierra Nevada, high-severity crown fires, though infrequent on any particular area, "may extend over a few hundred acres" in patches [p. 31; see also Plate V, Fig. 2, Plate VII, Fig. 2, Plate VIII, Plate IX, Figs. 1 and 2, and Plate X, Fig. 1], with some early-successional areas, resulting from high-severity fire patches, covering 5,000 acres in size or more [pp. 42-43]. The authors distinguished high-severity fire patches of this size from more "extensive" patches occurring in the northern Rocky Mountains [p. 31], where high-severity fire patches occasionally reach tens of thousands, or hundreds of thousands, of acres in size, and noted that patches of such enormous size were "almost" unknown in Sierra Nevada ponderosa pine and mixed-conifer forests. Within unlogged areas, the authors noted many large early-successional habitat patches, dominated by montane chaparral and young, regenerating conifer forest, and explained that such areas were the result of past severe fire because: a) patches of mature/old forest and individual surviving trees were found interspersed within these areas, and were found adjacent to these areas, indicating past forest; b) snags and stumps*

of fallen snags, as well as downed logs from fallen snags, were abundant in these areas; c) the species of chaparral found growing in these areas are known to sprout abundantly following severe fire; and d) natural conifer regeneration was found on most of the area [p. 42], often growing through complete chaparral cover [p. 43].)

Show, S.B. and Kotok, E.I. 1925. Fire and the forest (California pine region). United States Department of Agriculture Department Circular 358, Washington, D.C. *(Historically, within the ponderosa pine and mixed-conifer/pine belt of the Sierra Nevada, 1 acre out of every 7 on average was dominated by montane chaparral and young regenerating conifer forest following high-severity fire [Footnote 2, and Figs. 4 and 5]; on one national forest 215,000 acres out of 660,000 was early-successional habitat from severe fire [p. 17].)*

Stephenson, N. L.; Parsons, D.J.; Swetnam, T.W. 1991. Restoring natural fire to the sequoia - mixed conifer forest: should intense fire play a role? Proceedings of the Tall Timbers Fire Ecology Conference 17:321-337.

Taylor A.H. 2002. Evidence for pre-suppression high-severity fire on mixed conifer forests on the west shore of the Lake Tahoe Basin. Final report. South Lake Tahoe (CA): USDA Forest Service, Lake Tahoe Basin Management Unit.

USFS (United States Forest Service). 1910-1912. Timber Survey Field Notes, 1910-1912, U.S. Forest Service, Stanislaus National Forest. Record Number 095-93-045, National Archives and Records Administration—Pacific Region, San Bruno, California, USA. *(Surveys were conducted within primary forest to evaluate timber production potential in 16.2-ha (40-acre) plots within each 259.1-ha (640-acre) section in ponderosa pine and mixed-conifer forest on the westside of the Stanislaus National Forest, using one or more 1.62-ha transect per plot. Surveyors noted that surveys for individual tree size, density and species were not conducted in areas that had experienced high-severity fire sufficiently recently such that the regenerating areas did not yet contain significant merchantable sawtimber. Surveyors noted that the dominant vegetation cover across the majority of many 259.1-ha sections was montane chaparral and young conifer regeneration following high-severity fire. For example (from a typical township in the data set): a) T1S, R18E, Section 9 (“Severe fire went through [this section] years ago and killed most of the trees and land was reverted to brush”, noting “several large dense sapling stands” and noting that merchantable timber existed on only four of sixteen 16.2-ha plots in the section); b) T1S, R18E, Section 14 (“Fires have killed most of timber and most of section has reverted to brush”); c) T1S, R18E, Section 15 (same); d) T1S, R18E, Section 23 (“Most of timber on section has been killed by fires which occurred many years ago”); T1S, R18E, Section 21 (“Old fires killed most of timber on this section and most of area is now brushland”).)*

Whitlock, C., J. Marlon, C. Briles, A. Brunelle, C. Long and P. Bartlein, 2008. Long-term relations among fire, fuel, and climate in the north-western US based on lake-sediment studies. International Journal of Wildland Fire 17: 72-83.

- Whitlock, C., P.E. Higuera, D.B. McWethy, and C.E. Briles. 2010. Paleoecological perspectives on fire ecology: revisiting the fire-regime concept. *The Open Ecology Journal* 3: 6-23.
- Williams, M.A. & Baker, W.L. 2010. Bias and error in using survey records for ponderosa pine landscape restoration. *Journal of Biogeography* 37, 707–721.
- Williams, M.A. & Baker, W.L. 2011. Testing the accuracy of new methods for reconstructing historical structure of forest landscapes using GLO survey data. *Ecological Monographs*, 81: 63–88.
- Williams, M.A., W.L. Baker. 2012a. Spatially extensive reconstructions show variable-severity fire and heterogeneous structure in historical western United States dry forests. *Global Ecology and Biogeography*. DOI: 10.1111/j.1466-8238.2011.00750.
- Williams, M.A., W.L. Baker. 2012b. Comparison of the higher-severity fire regime in historical (A.D. 1800s) and modern (A.D. 1984-2009) montane forests across 624,156 ha of the Colorado Front Range. *Ecosystems* DOI 10.1007/s10021-012-9549-8.
- Wills, R. D. & Stuart, J. D. 1994. Fire history and stand development of a Douglas-fir/hardwood forest in northern California. *Northwest Science* 68, 205-212.

2) **Historic high-severity fire occurrence and extent cannot be addressed with fire-scar studies that sample individual large trees across the landscape, because such methods miss patches where no trees survive, and even sampled trees may have survived past high-severity fire; and fire return intervals based upon fire-scar data greatly underestimate the actual fire rotation interval in any given area.**

- Baker, W.L. and D.S. Ehle. 2001. Uncertainty in surface-fire history: the case of ponderosa pine forests in the western United States. *Canadian Journal of Forest Research* 31: 1205-1226. *(Methodological flaws in fire-scar studies—including targeting multiple-scar trees, the often incorrect assumption that fire scars in the same year in trees hundreds of meters, or several kilometers, apart correspond to an entire area burning [as opposed to spot fires from multiple lightning strikes] and the failure to account for the time interval between tree origin and the first fire scar--lead to a substantial underestimation of mean fire return interval and the range of intervals [2-25 years versus 22-308 years]).*
- Beaty, R.M., and A.H. Taylor. 2001. Spatial and temporal variation of fire regimes in a mixed conifer forest landscape, Southern Cascades, USA. *Journal of Biogeography* 28: 955–966. *(Pre-fire suppression composite fire return intervals were less than 8 years while fire rotation intervals were 28 years in the same forests during the same time period in mixed conifer forests [Tables 5 and 6].)*
- Bekker, M. F. and Taylor, A. H. 2001. Gradient analysis of fire regimes in montane forests of the southern Cascade Range, Thousand Lakes Wilderness, California, USA. *Plant Ecology* 155: 15-28. *(Fire rotation intervals were 4 to 6 times longer than composite fire return intervals in pre-fire suppression mixed conifer forests. [Table 2].)*

Veblen, T.T. 2003. Key issues in fire regime research for fuels management and ecological restoration. Omi PN, Joyce LA, technical editors. Fire, fuel treatments and ecological restoration: conference proceedings. USDA Forest Service: Fort Collins, CO. Proceedings RMRS-P-29. p 259-276.

- 3) **High-severity fire patches, including large patches, create very biodiverse, ecologically important, and unique habitat (often called “snag forest habitat”), which often has higher species richness and diversity than unburned old forest; many wildlife species use this forest habitat type more than any other, and old forest species select it for foraging, while some rare species, such as the Black-backed Woodpecker, depend upon it for both nesting and foraging.**

Buchalski, M.R., J.B. Fontaine, P.A. Heady III, J.P. Hayes, and W.F. Frick. 2013. Bat response to differing fire severity in mixed-conifer forest, California, USA. PLOS ONE 8: e57884. *(In mixed-conifer forests of the southern Sierra Nevada, rare myotis bats were found at greater levels in unmanaged high-severity fire areas of the McNally fire than in lower fire severity areas or unburned forest.)*

Burnett, R.D., P. Taillie, and N. Seavy. 2010. Plumas Lassen Study 2009 Annual Report. U.S. Forest Service, Pacific Southwest Region, Vallejo, CA. *(Bird species richness was approximately the same between high-severity fire areas and unburned mature/old forest at 8 years post-fire in the Storrie fire, and total bird abundance was greatest in the high-severity fire areas of the Storrie fire [Figure 4]. Nest density of cavity-nesting species increased with higher proportions of high-severity fire, and was highest at 100% [Figure 8]. The authors noted that “[o]nce the amount of the plot that was high severity was over 60% the density of cavity nests increased substantially”, and concluded that “more total species were detected in the Moonlight fire which covers a much smaller geographic area and had far fewer sampling locations than the [unburned] green forest.”)*

Burnett, R.D., P. Taillie, and N. Seavy. 2011. Plumas Lassen Study 2010 Annual Report. U.S. Forest Service, Pacific Southwest Region, Vallejo, CA.

Donato, D.C., J.B. Fontaine, W.D. Robinson, J.B. Kauffman, and B.E. Law. 2009. Vegetation response to a short interval between high-severity wildfires in a mixed-evergreen forest. Journal of Ecology 97: 142-154. *(The high-severity re-burn [high-severity fire occurring 15 years after a previous high-severity fire] had the highest plant species richness and total plant cover, relative to high-severity fire alone [no re-burn] and unburned mature/old forest; and the high-severity fire re-burn area had over 1,000 seedlings/saplings per hectare of natural conifer regeneration.)*

Fontaine, J.B., D.C. Donato, W.D. Robinson, B.E. Law, and J.B. Kauffman. 2009. Bird communities following high-severity fire: response to single and repeat fires in a mixed evergreen forest, Oregon, USA. Forest Ecology and Management 257: 1496-1504. *(Bird*

species richness was not significantly different between high-severity re-burn, high-severity burn alone, and unburned old-growth forest, but was numerically highest in areas burned once by high-severity fire 17-18 years earlier, and in high-severity re-burn areas. Total bird abundance was higher in the high-severity fire area, at 17-18 years post-fire, than in the unburned old-growth forest [Figs. 3a and 3b].)

Haney, A., S. Apfelbaum, and J.M. Burris. 2008. Thirty years of post-fire succession in a southern boreal forest bird community. *The American Midland Naturalist* 159: 421-433. *(By 30 years after high-severity fire, bird species richness increased 56% relative to pre-fire mature unburned forest.)*

Hanson, C. T. and M. P. North. 2008. Postfire woodpecker foraging in salvage-logged and unlogged forests of the Sierra Nevada. *Condor* 110: 777-782. *(Black-backed woodpeckers depend upon dense, mature/old forest that has recently experienced higher-severity fire, and has not been salvage logged.)*

Hutto, R. L. 1995. Composition of bird communities following stand-replacement fires in Northern Rocky Mountain (U.S.A.) conifer forests. *Conservation Biology* 9: 1041-1058.

Hutto, R. L. 2008. The ecological importance of severe wildfires: Some like it hot. *Ecological Applications* 18:1827-1834.

Kotliar, N.B., S.J. Hejl, R.L. Hutto, V.A. Saab, C.P. Melcher, and M.E. McFadzen. 2002. Effects of fire and post-fire salvage logging on avian communities in conifer-dominated forests of the western United States. *Studies in Avian Biology* 25: 49-64.

Malison, R.L., and C.V. Baxter. 2010. The fire pulse: wildfire stimulates flux of aquatic prey to terrestrial habitats driving increases in riparian consumers. *Canadian Journal of Fisheries and Aquatic Sciences* 67: 570-579. *(In ponderosa pine and Douglas-fir forests of Idaho at 5-10 years post-fire, levels of aquatic insects emerging from streams were two and a half times greater in high-severity fire areas than in unburned mature/old forest, and bats were nearly 5 times more abundant in riparian areas with high-severity fire than in unburned mature/old forest.)*

Raphael, M.G., M.L. Morrison, and M.P. Yoder-Williams. 1987. Breeding bird populations during twenty-five years of postfire succession in the Sierra Nevada. *The Condor* 89: 614-626. *(At 25 years after high-severity fire, total bird abundance was slightly higher in snag forest than in unburned old forest in eastside mixed-conifer forest of the northern Sierra Nevada; and bird species richness was 40% higher in snag forest habitat. In earlier post-fire years, woodpeckers were more abundant in snag forest, but were similar to unburned by 25 years post-fire, while flycatchers and species associated with shrubs continued to increase to 25 years post-fire.)*

Roberts, S.L. 2008. The effects of fire on California spotted owls and their mammalian prey in the central Sierra Nevada, California. Ph.D. Dissertation, University of California at Davis.

(California spotted owl reproduction was 60% higher in a mixed-severity fire area [no salvage logging] than in unburned mature/old forest.)

Schieck, J., and S.J. Song. 2006. Changes in bird communities throughout succession following fire and harvest in boreal forests of western North America: literature review and meta-analyses. *Canadian Journal of Forest Research* 36: 1299-1318. ***(Bird species richness increased up to 30 years after high-severity fire, then decreased in mid-successional forest [31-75 years old], and increased again in late-successional forest [>75 years]).***

Sestrich, C.M., T.E. McMahon, and M.K. Young. 2011. Influence of fire on native and nonnative salmonid populations and habitat in a western Montana basin. *Transactions of the American Fisheries Society* 140: 136-146. ***(Native Bull and Cutthroat trout tended to increase with higher fire severity, particularly where debris flows occurred. Nonnative brook trout did not increase.)***

Siegel, R. B., R. L. Wilkerson, and D. L. Mauer. 2008. Black-backed Woodpecker (*Picoides arcticus*) surveys on Sierra Nevada national forests: 2008 pilot study. The Institute for Bird Populations, Point Reyes, CA.

Siegel, R.B., J.F. Saracco, and R.L. Wilkerson. 2010. Management Indicator Species (MIS) surveys on Sierra Nevada national forests: Black-backed Woodpecker. 2009 Annual Report. The Institute for Bird Populations, Point Reyes, CA.

4) Black-backed Woodpeckers rely upon large patches (generally at least 200 acres per pair) of recently killed trees (typically less than 8 years post-mortality) with very high densities of medium and large snags (usually at least 80-100 per acre), and any significant level of post-fire salvage logging largely eliminates nesting and foraging potential.

Burnett, R.D., P. Taillie, and N. Seavy. 2011. Plumas Lassen Study 2010 Annual Report. U.S. Forest Service, Pacific Southwest Region, Vallejo, CA. ***(Black-backed Woodpecker nesting was eliminated by post-fire salvage. See Figure 11 [showing nest density on national forest lands not yet subjected to salvage logging versus private lands that had been salvage logged.)***

Burnett, R.D., M. Preston, and N. Seavy. 2012. Plumas Lassen Study 2011 Annual Report. U.S. Forest Service, Pacific Southwest Region, Vallejo, CA. ***(Black-backed Woodpecker potential occupancy rapidly approaches zero when less than 40-80 snags per acre occur, or are retained (Burnett et al. 2012, Fig. 8 [occupancy dropping towards zero when there are fewer than 4-8 snags per 11.3-meter radius plot—i.e., less than 4-8 snags per 1/10th-acre, or less than 40-80 snags per acre.)***

Hanson, C. T. and M. P. North. 2008. Postfire woodpecker foraging in salvage-logged and unlogged forests of the Sierra Nevada. *Condor* 110:777–782. ***(Black-backed Woodpeckers selected dense, old forests that experienced high-severity fire, and avoided salvage logged areas [see Tables 1 and 2].)***

Hutto, R. L. 2008. The ecological importance of severe wildfires: Some like it hot. *Ecological Applications* 18:1827–1834. (**Figure 4a, showing about 50% loss of Black-backed Woodpecker post-fire occupancy due to moderate pre-fire logging [consistent with mechanical thinning] in areas that later experienced wildland fire.**)

Odion, D.C., and Hanson, C.T. 2013. Projecting impacts of fire management on a biodiversity indicator in the Sierra Nevada and Cascades, USA: the Black-backed Woodpecker. *The Open Forest Science Journal* 6: 14-23 (in press). (**High-severity fire, which creates primary habitat for Black-backed Woodpeckers, has declined by sixfold since the early 20th century in the Sierra Nevada and eastern Oregon Cascades due to fire suppression. Further, the current rate of high-severity fire in mature/old forest (which creates primary, or high suitability, habitat for this species) in the Sierra Nevada and eastern Oregon Cascades is so low, and recent high-severity fire in mature/old forest comprises such a tiny percentage of the overall forested landscape currently (0.66%, or about 1/150th of the landscape), that even if high-severity fire in mature/old forest was increased by several times, it would only amount to a very small proportional reduction in mature/old forest, while getting Black-backed Woodpecker habitat closer to its historical, natural levels. Conversely, the combined effect of a moderate version of current forest management—prefire thinning of 20% of the mature/old forest (in order to enhance fire suppression) over the next two decades, combined with post-fire logging of one-third of the primary Black-backed Woodpecker habitat, would reduce primary Black-backed Woodpecker habitat to an alarmingly low 0.20% (1/500th) of the forested landscape, seriously threatening the viability of Black-backed Woodpecker populations.**)

Rota, C.T. 2013. Not all forests are disturbed equally: population dynamics and resource selection of Black-backed Woodpeckers in the Black Hills, South Dakota. Ph.D. Dissertation, University of Missouri-Columbia, MO. (**Rota (2013) finds that Black-backed Woodpeckers only maintain stable or increasing populations (i.e., viable populations) in recent wildland fire areas occurring within dense mature/older forest (which have very high densities of large wood-boring beetle larvae due to the very high densities of medium/large fire-killed trees). And, while Black-backed are occasionally found in unburned forest or prescribed burn areas, unburned "beetle-kill" forests (unburned forest areas with high levels of tree mortality from small pine beetles) and lower-intensity prescribed burns have declining populations of Black-backed Woodpeckers (with the exception of a tiny percentage of beetle-kill areas). The study shows that unburned beetle-kill forests do not support viable populations, but very high snag-density beetle-kill areas tend to slow the population decline of Black-backed Woodpeckers in between occurrences of wildland fire. Population decline rates are alarmingly fast in low-intensity prescribed burn areas, indicating that such areas do not provide suitable habitat. Black-backed Woodpeckers are highly specialized and adapted to prey upon wood-boring beetle larvae found predominantly in recent higher-severity wildland fire areas. Moreover, while Black-backed Woodpeckers are naturally camouflaged against the charred bark of fire-killed trees, they are more conspicuous in unburned forests, or low-severity burned forests, and are much more vulnerable to predation by raptors in such areas. For this reason, even when a Black-backed Woodpecker pair does successfully reproduce in unburned forest or low-severity fire areas,**

both juveniles and adults have much lower survival rates than in higher-severity wildland fire areas.)

Saab, V.A., R.E. Russell, and J.G. Dudley. 2009. Nest-site selection by cavity-nesting birds in relation to postfire salvage logging. *Forest Ecology and Management* 257:151–159. (*Black-backed Woodpeckers select areas with about 325 medium and large snags per hectare [about 132 per acre], and nest-site occupancy potential dropped to near zero when snag density was below about 270 per hectare, or about 109 per acre [see Fig. 2A, showing 270 snags per hectare as the lower boundary of the 95% confidence interval].*)

Seavy, N.E., R.D. Burnett, and P.J. Taille. 2012. Black-backed woodpecker nest-tree preference in burned forests of the Sierra Nevada, California. *Wildlife Society Bulletin* 36: 722-728. (*Black-backed Woodpeckers selected sites with an average of 13.3 snags per 11.3-meter radius plot [i.e., 0.1-acre plot], or about 133 snags per acre.*)

Siegel, R.B., M.W. Tingley, and R.L. Wilkerson. 2011. Black-backed Woodpecker MIS surveys on Sierra Nevada national forests: 2010 Annual Report. A report in fulfillment of U.S. Forest Service Agreement No. 08-CS-11052005-201, Modification #2; U.S. Forest Service Pacific Southwest Region, Vallejo, CA. (*Black-backed woodpecker occupancy declines dramatically by 5-7 years post-fire relative to 1-2 years post-fire, and approaches zero by 10 years post-fire [Fig. 15a].*)

Siegel, R.B., M.W. Tingley, R.L. Wilkerson, M.L. Bond, and C.A. Howell. 2013. Assessing home range size and habitat needs of Black-backed Woodpeckers in California: Report for the 2011 and 2012 field seasons. Institute for Bird Populations. (*Black-backed woodpeckers strongly select large patches of higher-severity fire with high densities of medium and large snags, generally at least 100 to 200 hectares (roughly 250 to 500 acres) per pair, and post-fire salvage logging eliminates Black-backed woodpecker foraging habitat [see Fig. 13, showing almost complete avoidance of salvage logged areas]. Suitable foraging habitat was found to have more than 17-20 square meters per hectare of recent snag basal area [pp. 45, 68-70], and suitable nesting habitat was found to average 43 square meters per hectare of recent snag basal area and range from 18 to 85 square meters to hectare [p. 59, Table 13]. Moreover, Appendix 2, Fig. 2 indicates that the Sierra Nevada population of Black-backed Woodpeckers is genetically distinct from the Oregon Cascades population, though additional work needs to be conducted to determine just how distinct the two populations are.*)

Tarbill, G.L. 2010. Nest site selection and influence of woodpeckers on recovery in a burned forest of the Sierra Nevada. Master's Thesis, California State University, Sacramento. (*In post-fire eastside pine and mixed-conifer forests of the northern Sierra Nevada, Black-backed woodpeckers strongly selected stands with very high densities of medium and large snags, with well over 200 such snags per hectare on average at nest sites [Table 2], and nesting potential was optimized at 250 or more per hectare, dropping to very low levels below 100 to 200 per hectare [Fig. 5b].*)

5) **California Spotted Owls preferentially select unmanaged high-severity fire areas for foraging, have higher reproduction in mixed-severity fire areas than in unburned forests, and do not have reduced occupancy in areas dominated by moderate- and high-severity fire.**

Bond, M. L., D. E. Lee, R. B. Siegel, & J. P. Ward, Jr. 2009a. Habitat use and selection by California Spotted Owls in a postfire landscape. *Journal of Wildlife Management* 73: 1116-1124. (*In a radiotelemetry study, California spotted owls preferentially selected high-severity fire areas, which had not been salvage logged, for foraging.*)

Franklin, A.B., D.R. Anderson, R.J. Gutierrez, and K.P. Burnham. 2000. Climate, habitat quality, and fitness in northern spotted owl populations in northwestern California. *Ecological Monographs* 70: 539-590. (*The authors found that stable or increasing populations of spotted owls resulted from a mix of dense old forest and complex early seral habitat, and less than approximately 25% complex early seral habitat in the home range was associated with declining populations [Fig. 10]; the authors emphasized that the complex early seral habitat was consistent with high-severity fire effects, and inconsistent with clearcut logging.*)

Lee, D.E., M.L. Bond, and R.B. Siegel. 2012. Dynamics of breeding-season site occupancy of the California spotted owl in burned forests. *The Condor* 114: 792-802. (*Mixed-severity wildland fire, averaging 32% high-severity fire effects, did not decrease California spotted owl territory occupancy, but post-fire salvage logging appeared to adversely affect occupancy.*)

Roberts, S.L. 2008. The effects of fire on California spotted owls and their mammalian prey in the central Sierra Nevada, California. Ph.D. Dissertation, University of California at Davis. (*California spotted owl reproduction was 60% higher in a mixed-severity fire area [no salvage logging] than in unburned mature/old forest.*)

Seamans, M.E., and R.J. Gutiérrez. 2007. Habitat selection in a changing environment: the relationship between habitat alteration and spotted owl territory occupancy and breeding dispersal. *The Condor* 109: 566-576. (*The authors found that commercial logging of as little as 20 hectares, or about 50 acres, in spotted owl home ranges significantly reduced occupancy.*)

6) **Emerging data are indicating that Pacific fishers benefit from forests dominated by fir and cedar, with dense understories and high snag levels, and fishers may benefit from some mixed-severity fire as well.**

Hanson, C.T. (in preparation 2013). Pacific fisher habitat use of a heterogeneous post-fire and unburned landscape in the southern Sierra Nevada, California, USA. (*Pacific fishers are using pre-fire mature/old forest that experienced moderate/high-severity fire more than expected based upon availability, just as fishers are selecting dense, mature/old forest in its unburned state as well. When fishers are near fire perimeters, they strongly select the burned side of the fire edge. Both males and female fishers are using large mixed-severity*

fire areas, such as the McNally fire, including several kilometers into the fire area.)

Hanson, C.T., and D.C. Odion. 2013. Is fire severity increasing in the Sierra Nevada mountains, California, USA? *In review in International Journal of Wildland Fire. (All current modeling studies on relative risks to Pacific fishers of mechanical thinning versus wildland fire base assessments on the assumption of 90% to 100% tree mortality from fire, while actual mortality rates are far lower).*

Purcell, K.L., A.K. Mazzoni, S.R. Mori, and B.B. Boroski. 2009. Resting structures and resting habitat of fishers in the southern Sierra Nevada, California. *Forest Ecology and Management* 258: 2696-2706. *(High snag density was one of the two most important factors for fisher rest site occupancy, with snag basal area at occupied sites averaging about 31 square feet per acre [converted from metric to English, and from plot scale to per-acre], which was about 2.5 times higher than random sites.)*

Sweitzer, R. (unpublished data). *(Fishers are predominantly using incense cedar and white fir as den trees (see bottom left of May 1 2012 - Fisher Field Trip Poster at <http://snamp.cnr.berkeley.edu/documents/446/>).*

Underwood, E.C., J.H. Viers, J.F. Quinn, and M. North. 2010. Using topography to meet wildlife and fuels treatment objectives in fire-suppressed landscapes. *Environmental Management* 46: 809-819. *(Fishers are selecting the densest forest, dominated by fir and cedar, with the highest densities of small and medium-sized trees, and the highest snag levels.)*

Zielinski, W.J., N.P. Duncan, E.C. Farmer, R.L. Truex, A.P. Cleavenger, and R.H. Barrett. 1999. Diet of fishers (*Martes pennanti*) at the southernmost extent of their range. *Journal of Mammalogy* 80: 961-971. *(The majority of the prey taxa identified in the fisher's diet are species associated with complex early-successional habitat, consistent with higher-severity fire effects.)*

Zielinski, W.J., R.L. Truex, J.R. Dunk, and T. Gaman. 2006. Using forest inventory data to assess fisher resting habitat suitability in California. *Ecological Applications* 16: 1010-1025. *(The two most important factors associated with fisher rest sites are high canopy cover and high densities of small and medium-sized trees less than 50 cm in diameter [Tables 1 and 3].)*

Zielinski, W.J., J.A. Baldwin, R.L. Truex, J.M. Tucker, and P.A. Flebbe. 2013. Estimating trend in occupancy for the southern Sierra fisher (*Martes pennanti*) population. *Journal of Fish and Wildlife Management* 4: 1-17. *(The authors investigated fisher occupancy in three subpopulations of the southern Sierra Nevada fisher population: the western slope of Sierra National Forest; the Greenhorn mountains area of southwestern Sequoia National Forest; and the Kern Plateau of southeastern Sequoia National Forest area, using baited track-plate stations. The Kern Plateau area is predominantly post-fire habitat [mostly unaffected by salvage logging] from several large fires occurring since 2000, including the Manter fire of 2000 and the McNally fire of 2002. The baited track-plate stations used for*

the study included these fire areas [Fig. 2]. Mean annual fisher occupancy at detection stations was lower on Sierra National Forest than on the Kern Plateau. Occupancy was trending downward on Sierra National Forest, and upward on the Kern Plateau, though neither was statistically significant, possibly due to a small data set.)

7) Post-fire salvage logging substantially reduces, and often locally eliminates, wildlife species strongly associated with snag forest habitat created by high-severity fire patches.

Burnett, R.D., P. Taillie, and N. Seavy. 2011. Plumas Lassen Study 2010 Annual Report. U.S. Forest Service, Pacific Southwest Region, Vallejo, CA. (*Black-backed Woodpecker nesting was eliminated by post-fire salvage. See Figure 11 [showing nest density on national forest lands not yet subjected to salvage logging versus private lands that had been salvage logged.]*)

Burnett, R.D., M. Preston, and N. Seavy. 2012. Plumas Lassen Study 2011 Annual Report. U.S. Forest Service, Pacific Southwest Region, Vallejo, CA. (*Overall bird diversity is substantially reduced by post-fire logging. See Figures 6 and 7.*)

Hanson, C. T. and M. P. North. 2008. Postfire woodpecker foraging in salvage-logged and unlogged forests of the Sierra Nevada. Condor 110:777–782. (*See Tables 1 and 2.*)

Hutto, R. L. 1995. Composition of bird communities following stand-replacement fires in Northern Rocky Mountain (U.S.A.) conifer forests. Conservation Biology 9:1041–1058.

Hutto, R. L. 2008. The ecological importance of severe wildfires: Some like it hot. Ecological Applications 18:1827–1834.

Siegel, R.B., M.W. Tingley, R.L. Wilkerson, and M.L. Bond. 2012b. Assessing home range size and habitat needs of Black-backed Woodpeckers in California: 2011 Interim Report. Institute for Bird Populations. A report in fulfillment of U.S. Forest Service Agreement No. 08-CS-11052005-201, Modification 3; U.S. Forest Service, Pacific Southwest Region, Vallejo, CA. (*See Figure 10, showing almost complete avoidance of salvage logged areas by Black-backed Woodpeckers in a radiotelemetry study in the southern Cascades in California.*)

8) Natural, historic forests (pre-fire suppression, pre-logging) in the Sierra Nevada and southern dry Cascades were structurally complex, with a high degree of heterogeneity from natural disturbance, in terms of chaparral patch extent, stand structure, density, species composition—including stands dominated by fir and cedar with dense understories as a significant part of the mix in both ponderosa-pine/Jeffrey-pine and mixed-conifer forests.

Baker, W.L. 2012. Implications of spatially extensive historical data from surveys for restoring dry forests of Oregon's eastern Cascades. Ecosphere 3(3): article 23. (*Historic mixed-conifer forests contained some open and park-like areas, but such areas were a minority.*)

The area was, overall, dominated by denser forests with substantial shrub cover and understory conifer density—small trees comprised over 50% of all trees on over 72% of the forest.)

Duren, O.C., P.S. Muir, and P.E. Hosten. 2012. Vegetation change from the Euro-American settlement era to the present in relation to environment and disturbance in southwest Oregon. *Northwest Science* 86: 310-328. *(Historic mixed-conifer forests in the southern dry Cascades were predominantly closed, rather than open-canopy.)*

Hessburg, P. F., R. B. Salter, and K. M. James. 2007. Re-examining fire severity relations in pre-management era mixed conifer forests: inferences from landscape patterns of forest structure. *Landscape Ecology* 22:5-24. *(Historic mixed-conifer forests of eastern Oregon Cascades were mainly mixed- and high-severity, and were dominated by dense, early- and mid-successional forests regenerating from past higher-severity fire, rather than by open and park-like old-growth forests.)*

Leiberg, J. B. 1902. Forest conditions in the northern Sierra Nevada, California. USDI Geological Survey, Professional Paper No. 8. U.S. Government Printing Office, Washington, D.C. *(In the 19th century, prior to fire suppression, composition of mixed-conifer forests in the central and northern Sierra Nevada was quantified in unlogged areas for several watersheds, and in dozens of specific locations within watersheds. The study reported that, while some of these areas were open and parklike stands dominated by ponderosa pine, Jeffrey pine, and sugar pine, the majority were dominated by white fir, incense-cedar, and Douglas-fir, especially on north-facing slopes and on lower slopes of subwatersheds; such areas were predominantly described as dense, often with “heavy underbrush” from past mixed-severity fire. Natural heterogeneity, resulting from fire, often involved dense stands of old forest adjacent to snag forest patches of standing fire-killed trees and montane chaparral with regenerating young conifers: “All the slopes of Duncan Canyon from its head down show the same marks of fire—dead timber, dense undergrowth, stretches of chaparral, thin lines of trees or small groups rising out of the brush, and heavy blocks of forest surrounded by chaparral.” [p. 171])*

Nagel, T.A. and Taylor, A.H. 2005. Fire and persistence of montane chaparral in mixed conifer forest landscapes in the northern Sierra Nevada, Lake Tahoe Basin, California, USA. *J. Torrey Bot. Soc.* 132: 442-457.

USFS (United States Forest Service). 1910-1912. Timber Survey Field Notes, 1910-1912, U.S. Forest Service, Stanislaus National Forest. Record Number 095-93-045, National Archives and Records Administration—Pacific Region, San Bruno, California, USA. *(Historic ponderosa pine and mixed-conifer forests of the central/southern Sierra Nevada [western slope] varied widely in stand density and composition; open and park-like pine-dominated stands comprised a significant portion of the lower montane and foothill zones, but dense stands dominated by fir and cedar, and by small/medium-sized trees, dominated much of the middle montane zone. It should be noted that the old-growth forests chosen for study by Scholl and Taylor 2010 and Collins et al. 2011b comprised only a very small portion of the 1910-1912 Stanislaus data set.)*

Williams, M.A., W.L. Baker. 2012a. Spatially extensive reconstructions show variable-severity fire and heterogeneous structure in historical western United States dry forests. *Global Ecology and Biogeography*. DOI: 10.1111/j.1466-8238.2011.00750.

9) **The scientific data indicate that current rates of high-severity fire (rotation intervals) in the Sierra Nevada and southern Cascades are likely lower (longer rotation intervals) than historic rates, indicating less high-severity fire overall.**

Baker, W.L. 2012. Implications of spatially extensive historical data from surveys for restoring dry forests of Oregon's eastern Cascades. *Ecosphere* 3(3): article 23. (*In dry mixed-conifer forests of the southern Cascades, the historic high-severity fire rotation was 435 years, and the combined mixed/high-severity rotation was 165 years.*)

Bekker, M. F. and Taylor, A. H. 2001. Gradient analysis of fire regimes in montane forests of the southern Cascade Range, Thousand Lakes Wilderness, California, USA. *Plant Ecology* 155: 15-28. (*Approximately 50% to 60% of the mixed-conifer forest in an unlogged area of the southern Cascades in California experienced high-severity fire over a 76-year period prior to fire suppression, indicating a high-severity fire rotation interval of 150-200 years.*)

Collins, B.M., and S.L. Stephens. 2010. Stand-replacing patches within a mixed-severity fire regime: quantitative characterization using recent fires in a long-established natural fire area. *Landscape Ecology* 25: 927-939. (*In a modern "reference" forest condition within mixed-conifer/fir forests in Yosemite National Park, 15% of the area experienced high-severity fire over a 33-year period—a high-severity fire rotation interval of approximately 223 years.*)

Miller, J.D., B.M. Collins, J.A. Lutz, S.L. Stephens, J.W. van Wageningen, and D.A. Yasuda. 2012b. Differences in wildfires among ecoregions and land management agencies in the Sierra Nevada region, California, USA. *Ecosphere* 3: Article 80. (*Current high-severity fire rotation interval in the Sierra Nevada management region overall is over 800 years. The authors recommended increasing high-severity fire amounts [i.e., decreasing rotation intervals] in the Cascades-Modoc region and on the western slope of the Sierra Nevada, where the current high-severity fire rotation is 859 to 4650 years [Table 3]. The authors noted that "high-severity rotations may be too long in most Cascade-Modoc and westside NF locations, especially in comparison to Yosemite..."*).

Minnich, R.A., M.G. Barbour, J.H. Burk, and J. Sosa-Ramirez. 2000. Californian mixed-conifer forests under unmanaged fire regimes in the Sierra San Pedro Martir, Baja California, Mexico. *Journal of Biogeography* 27:105–129. (*High-severity fire rotation interval in reference forests that had not been logged or fire-suppressed was 300 years.*)

Stephens, S.L., R.E. Martin, and N.E. Clinton. 2007. Prehistoric fire area and emissions from California's forests, woodlands, shrublands, and grasslands. *Forest Ecology and Management* 251:205–216. (*Estimated high-severity fire proportion and frequency*

indicate historic high-severity fire rotation intervals of approximately 250 to 400 years in historic ponderosa pine and mixed-conifer forests in California.)

10) Contrary to widespread, popular assumptions, forest areas that have missed the largest number of fire return intervals in California's forests are burning predominantly at low/moderate-severity levels, and are not experiencing higher fire severity than areas that have missed fewer fire return intervals.

Miller JD, Skinner CN, Safford HD, Knapp EE, Ramirez CM (2012b) Trends and causes of severity, size, and number of fires in northwestern California, USA. *Ecological Applications* 22, 184-203.

van Wagtenonk, J.W., K.A. van Wagtenonk, and A.E. Thode. 2012. Factors associated with the severity of intersecting fires in Yosemite National Park, California, USA. *Fire Ecology* 8: 11-32. (*"The proportion burned in each fire severity class was not significantly associated with fire return interval departure class...[L]ow severity made up the greatest proportion within all three departure classes, while high severity was the least in each departure class (Figure 4)."*)

Odion, D.C., E.J. Frost, J.R. Strittholt, H. Jiang, D.A. DellaSala, and M.A. Moritz. 2004. Patterns of fire severity and forest conditions in the Klamath Mountains, northwestern California. *Conservation Biology* 18: 927-936.

Odion, D.C., and C.T. Hanson. 2006. Fire severity in conifer forests of the Sierra Nevada, California. *Ecosystems* 9: 1177-1189.

Odion, D.C., and C.T. Hanson. 2008. Fire severity in the Sierra Nevada revisited: conclusions robust to further analysis. *Ecosystems* 11: 12-15.

Odion, D. C., M. A. Moritz, and D. A. DellaSala. 2010. Alternative community states maintained by fire in the Klamath Mountains, USA. *Journal of Ecology*, doi: 10.1111/j.1365-2745.2009.01597.x.

11) Most studies of current fire trends in California's forests have not found an increase in fire severity, and studies are mixed on whether fire will increase, or decrease, in future decades as a result of climate change, depending upon the modeling assumptions used (e.g., hotter and drier versus warmer and wetter).

Collins, B.M., J.D. Miller, A.E. Thode, M. Kelly, J.W. van Wagtenonk, and S.L. Stephens. 2009. Interactions among wildland fires in a long-established Sierra Nevada natural fire area. *Ecosystems* 12:114–128. (*No increase in high-severity fire found.*)

Crimmins, S.L., et al. 2011. Changes in climatic water balance drive downhill shifts in plant species' optimum elevations. *Science* 331:324-327. (*Precipitation, and summer precipitation, were found to be increasing.*)

- Dillon, G.K., et al. 2011. Both topography and climate affected forest and woodland burn severity in two regions of the western US, 1984 to 2006. *Ecosphere* 2:Article 130. ***(No increase in fire severity was found in most forested regions of the western U.S., including no increasing trend of fire severity in forests of the Pacific Northwest and Inland Northwest, which extended into the northern portion of the Sierra Nevada management region.)***
- Gonzalez, P., R.P. Neilson, J.M. Lenihan, and R.J. Drapek. 2010. Global patterns in the vulnerability of ecosystems to vegetation shifts due to climate change. *Global Change and Biogeography* 19:755-768. ***(Precipitation has been increasing in the western U.S. [Fig. 1b], and a decrease in fire is projected over the 21st century in California's forests due to climate change, while increases are projected in desert areas east of the Sierra Nevada [Fig. 3b].)***
- Hamlet, A.F., P.W. Mote, M.P. Clark, D.P. Lettenmaier. 2007. Twentieth-century trends in runoff, evapotranspiration, and soil moisture in the western United States. *Journal of Climate* 20:1468-1486. ***(A trend of increasing precipitation was found in western U.S. forests.)***
- Hanson, C.T., D.C. Odion, D.A. DellaSala, and W.L. Baker. 2009. Overestimation of fire risk in the Northern Spotted Owl Recovery Plan. *Conservation Biology* 23:1314–1319. ***(Fire severity is not increasing in forests of the Klamath and southern Cascades or eastern Cascades.)***
- Hanson, C.T., D.C. Odion, D.A. DellaSala, and W.L. Baker. 2010. More-comprehensive recovery actions for Northern Spotted Owls in dry forests: Reply to Spies et al. *Conservation Biology* 24:334–337.
- Hanson, C.T., and D.C. Odion. 2013. Is fire severity increasing in the Sierra Nevada mountains, California, USA? *In press* in *International Journal of Wildland Fire*. ***(Hanson and Odion (revision in press 2013) conducted the first comprehensive assessment of fire intensity since 1984 in the Sierra Nevada using 100% of available fire intensity data, and, using Mann-Kendall trend tests (a common approach for environmental time series data—one which has similar or greater statistical power than parametric analyses when using non-parametric data sets, such as fire data), found no increasing trend in terms of high-intensity fire proportion, area, mean patch size, or maximum patch size. Hanson and Odion (revision in review 2013) checked for serial autocorrelation in the data, and found none, and used pre-1984 vegetation data (1977 Cal-Veg) in order to completely include any conifer forest experiencing high-intensity fire in all time periods since 1984 (the accuracy of this data at the forest strata scale used in the analysis was 85-88%). Hanson and Odion (revision in review 2013) also checked the results of Miller et al. (2009) and Miller and Safford (2012) for bias, due to the use of vegetation layers that post-date the fires being analyzed in those studies. Hanson and Odion (revision in review 2013) found that there is a statistically significant bias in both studies ($p = 0.032$ and $p = 0.021$, respectively), the effect of which is to exclude relatively more conifer forest experiencing high-intensity fire in the earlier years of the time series, thus creating the false appearance of an increasing***

trend in fire severity. Interestingly, Miller et al. (2012a), acknowledged the potential bias that can result from using a vegetation classification data set that post-dates the time series. In that study, conducted in the Klamath region of California, Miller et al. used a vegetation layer that preceded the time series, and found no trend of increasing fire severity. Miller et al. (2009) and Miller and Safford (2012) did not, however, follow this same approach. Hanson and Odion (revision in review 2013) also found that the regional fire severity data set used by Miller et al. (2009) and Miller and Safford (2012) disproportionately excluded fires in the earlier years of the time series, relative to the standard national fire severity data set (www.mtbs.gov) used in other fire severity trend studies, resulting in an additional bias which created, once again, the inaccurate appearance of relatively less high-severity fire in the earlier years, and relatively more in more recent years. The results of Hanson and Odion (revision in review 2013) are consistent with all other recent studies of fire intensity trends in California's forests that have used all available fire intensity data, including Collins et al. (2009) in a portion of Yosemite National Park, Schwind (2008) regarding all vegetation in California, Hanson et al. (2009) and Miller et al. (2012a) regarding conifer forests in the Klamath and southern Cascades regions of California, and Dillon et al. (2011) regarding forests of the Pacific (south to the northernmost portion of California) and Northwest.)

Krawchuk, M.A., M.A. Moritz, M. Parisien, J. Van Dorn, and K. Hayhoe. 2009. Global pyrogeography: the current and future distribution of wildfire. *PloS ONE* 4: e5102. *(Fire is projected to decrease in the Sierra Nevada management region over the next several decades due to climate change [Fig. 3].)*

Lenihan, J.M., D. Bachelet, R.P. Neilson, and R. Drapek. 2008. Response of vegetation distribution, ecosystem productivity, and fire to climate change scenarios for California. *Climatic Change* 87:S215-S230. *(Fire would increase moderately in California's forests in the coming decades if there are hotter and drier conditions [i.e., models analyzed assumed hotter/drier conditions].)*

Liu, Y., J. Stanturf, and S. Goodrick. 2010. Trends in global wildfire potential in a changing climate. *Forest Ecology and Management* 259:685-697. *(A decrease in fire is projected in California's forested regions over the 21st century due to climate change [Fig. 1].)*

McKenzie, et al. 2004. Z. Gedalof, D.L. Peterson, and P. Mote. 2004. Climatic change, wildfire, and conservation. *Conservation Biology* 18: 890-902. *(Fire was projected to decrease in California's forests in the coming decades from climate change, despite warming, due to increasing summer precipitation.)*

Miller, J.D., C.N. Skinner, H.D. Safford, E.E. Knapp, and C.M. Ramirez. 2012a. Trends and causes of severity, size, and number of fires in northwestern California, USA. *Ecological Applications* 22:184-203. *(No increase in fire severity was found in the Klamath region of California, which partially overlaps the Sierra Nevada management region.)*

Mote, P.W. 2003. Trends in temperature and precipitation in the Pacific Northwest during the twentieth century. *Northwest Science* 77:271–282. (*Steady increases in summer precipitation were found in the Pacific Northwest and Inland Northwest.*)

Schwind, B. compiler. 2008. Monitoring trends in burn severity: report on the Pacific Northwest and Pacific Southwest fires (1984 to 2005). U.S. Geological Survey Center for Earth Resources Observation and Science, Sioux Falls, South Dakota. Available from <http://www.mtbs.gov/reports/projectreports.htm> (accessed October 2008). (*No increase in fire severity was found in California, with all vegetation combined.*)

- 12) **Ecological resilience is enhanced by natural disturbance processes, and the heterogeneous habitat structures (e.g., snags, downed logs, montane chaparral patches, and patches of natural conifer regeneration following higher-severity fire and/or patches of beetle mortality) and natural successional stages resulting from such natural disturbance; the goal of consistently maintaining mature forest cover in a fire-adapted ecosystem is not ecological resilience but, rather, precisely the opposite: engineering resilience.**

Thompson, I., B. Mackey, S. McNulty, and A. Mosseler. 2009. Forest resilience, biodiversity, and climate change. United Nations Environment Programme (UNEP), Secretariat of the Convention on Biological Diversity, Montreal, Canada. Technical Series No. 43. 67 pp. (*The authors contrast ecological resilience, which pertains to the maintenance of the full complement of native biodiversity by maintaining active natural disturbance regimes, with engineering resilience, which pertains to the suppression of natural disturbance and the habitat structures and complex early-successional habitat created by such disturbance.*)

- 13) **Natural conifer regeneration is considerable following large, high-severity fire patches in mixed-conifer forests, indicating substantial natural resilience in these forests, including in the very rare circumstances in which a high-severity fire “reburn” occurs within a short timeframe.**

Collins, B.M., G. Roller, and S.L. Stephens. 2011. Fire and fuels at the landscape scale. Plumas Lassen Study: 2010 Annual Report. U.S. Forest Service, Pacific Southwest Research Station, Davis, CA. (*See pages 15-23, including Tables 5 and 6.*)

Donato, D.C., et al. 2009. Vegetation response to a short interval between high-severity wildfires in a mixed-evergreen forest. *Journal of Ecology* 97: 142-154.

Haire, S.L. and K. McGarigal. 2008. Inhabitants of landscape scars: succession of woody plants after large, severe forest fires in Arizona and New Mexico. *The Southwestern Naturalist* 53: 146-161. (*A high diversity of tree and shrub species naturally regenerates after severe fire [Table 1].*)

Haire, S.L. and K. McGarigal. 2010. Effects of landscape patterns of fire severity on regenerating ponderosa pine forests (*Pinus ponderosa*) in New Mexico and Arizona, USA. *Landscape Ecology* 25: 1055-1069. (*Natural post-fire conifer regeneration, within the*

same fire areas analyzed in Haire and McGarigal 2008, occurs in 100% mortality patches even 200 or more meters from the nearest live tree, and regeneration nearer to the live-tree edge occurs vigorously within a few years post-fire, increasing rapidly after 10-15 years post-fire [Fig. 5]. The proportion of the total high-severity fire area that is more than 200 meters from the nearest live-tree edge was relatively small [Fig.2].)

Shatford, J.P.A., D.E. Hibbs, and K.J. Puettmann. 2007. Conifer regeneration after forest fire in the Klamath-Siskiyou: how much, how soon? *Journal of Forestry* April/May 2007, pp. 139-146.

14) High-severity fire rotation intervals of 200 years, or somewhat less, still retain large proportions of late-successional/old-growth forest on the landscape, unlike even-aged logging rotations.

Cyr, D., S. Gauthier, Y. Bergeron, and C. Carcaillet. 2009. Forest management is driving the eastern North American boreal forest outside its natural range of variability. *Frontiers in Ecology and Environment* 7: 519-524. *(With a high-severity fire rotation of 200 years, approximately 27% of the forest is 100-200 years old, and approximately 34% of the forest is over 200 years old; and, even with a 100-year rotation for high-severity fire, approximately 25% of the forest is 100-200 years old, and approximately 14% is over 200 years old [Fig. 1]).*

15) Areas with higher tree mortality from native beetle species do not burn more severely when wildland fire occurs.

Bond, M.L., D.E. Lee, C.M. Bradley, and C.T. Hanson. 2009b. Influence of pre-fire tree mortality on fire severity in conifer forests of the San Bernardino Mountains, California. *The Open Forest Science Journal* 2: 41-47.

Donato, D.C., B.J. Harvey, W.H. Romme, M. Simard, and M.G. Turner. 2013. Bark beetle effects on fuel profiles across a range of stand structures in Douglas-fir forests of Greater Yellowstone. *Ecological Applications* 23: 3-20.

Simard, M., W.H. Romme, J.M. Griffin, and M.G. Turner. 2011. Do mountain pine beetle outbreaks change the probability of active crown fire in lodgepole pine forests? *Ecological Monographs* 81:3-24.

16) Selective logging and mechanical thinning operations substantially harm some of the rarest and most imperiled bird species, and can create an “ecological trap”.

Hutto, R. L. 2008. The ecological importance of severe wildfires: Some like it hot. *Ecological Applications* 18:1827–1834. *(Mechanical thinning and selective logging operations reduced Black-backed Woodpecker occupancy by about 50% in areas that subsequently experienced wildland fire, and even heavier pre-fire logging reduced post-fire occupancy by about 90% [Fig. 4a].)*

Manning, T., J.C. Hagar, and B.C. McComb. 2012. Thinning of young Douglas-fir forests decreases density of northern flying squirrels in the Oregon Cascades. *Forest Ecology and Management* 264: 115-124. (*Mechanical thinning harms a key prey species of the Northern Spotted Owl.*)

Meyer M.D., M.P. North, and D.A. Kelt. 2005. Short-term effects of fire and forest thinning on truffle abundance and consumption by *Neotamias speciosus* in the Sierra Nevada of California. *Canadian Journal of Forest Research* 35: 1061-1070. (*Mechanical thinning harms a key prey species of the California Spotted Owl.*)

Robertson, B.A., and R.L. Hutto. 2007. Is selectively harvested forest an ecological trap for Olive-sided Flycatchers? *The Condor* 109: 109-121. (*Selective logging, consistent with a moderate mechanical thinning operation, created conditions that superficially appeared similar to the open conditions associated with high-severity post-fire habitat upon which this species depends, but nest success in the logged areas was only about one-half of what it was in the naturally burned areas, indicating ecological trap conditions that threaten population viability in the logged areas.*)

Seamans, M.E., and R.J. Gutiérrez. 2007. Habitat selection in a changing environment: the relationship between habitat alteration and spotted owl territory occupancy and breeding dispersal. *The Condor* 109: 566-576. (*As little as 20 hectares of logging, including mechanical thinning, within the 400-hectare home range core area significantly reduced territory occupancy.*)

17) The combination of snags and downed logs, along with post-fire regenerating shrubs and conifers, results in maximal levels of total biomass and carbon sequestration in high-severity fire areas.

Keith, H., B.G. Mackey, and D.B. Lindenmayer. 2009. Re-evaluation of forest biomass carbon stocks and lessons from the world's most carbon-dense forests. *Proceedings of the National Academy of Sciences* 106: 11635-11640. (*The highest biomass and carbon sequestration is found in eucalypt forests of Australia that naturally experience periodic high-severity fire.*)

Powers, E.M., J.D. Marshall, J. Zhang, and L. Wei. 2013. Post-fire management regimes affect carbon sequestration and storage in a Sierra Nevada mixed conifer forest. *Forest Ecology and Management* 291: 268-277. (*In Sierra Nevada mixed conifer forests, the highest total aboveground carbon storage was found to occur in mature/old forest that experienced 100% tree mortality in wildland fire, and was not salvage logged or artificially replanted, relative to lightly burned old forest and salvage logged areas [Fig. 1b]).*

18) Vegetation management designed to protect homes from fire is ineffective and unnecessary beyond approximately 40 meters from individual homes.

Cohen, J.D. 2000. Preventing disaster: home ignitability in the Wildland-Urban Interface. *Journal of Forestry* 98: 15-21.

Cohen, J.D., and R.D. Stratton. 2008. Home destruction examination: Grass Valley Fire. U.S. Forest Service Technical Paper R5-TP-026b. U.S. Forest Service, Region 5, Vallejo, CA.

Compiled by:

Chad Hanson, Ph.D., Director
John Muir Project of Earth Island Institute
P.O. Box 697
Cedar Ridge, CA 95924
530-273-9290
cthanson1@gmail.com

Justin Augustine, Staff Attorney
Center for Biological Diversity
351 California St., Suite 600
San Francisco, CA 94104
415-436-9682, ext. 302
jaugustine@biologicaldiversity.org